The representation of synthetic biology in the Dutch media

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Author: K. (Kim) Hartman – Solis id: 3501752
Contact: kim.hartman@hotmail.com

Supervisor: Dr. M.C.P.J. (Marie-Christine) Knippels
Contact: m.c.p.j.knippels@uu.nl

ABSTRACT | Synthetic biology is a relatively new field of research. The promises are big and could have a lot of impact on people's lives. Therefore, people should feel empowered to have dialogue about upcoming issues, so they can act as responsible citizens when necessary. Dialogue about science is important, as we learned from past experiences with the biotechnology debate. It is thus of interest to look at what the current dialogue is about synthetic biology, because this knowledge could be used to understand main topics and to pinpoint possible problems, which in turn could help to empower people in social dialogue. Since the media is the main source of scientific information people have, and since the media can greatly influence the opinions and views of people, this study aimed to map the representation of synthetic biology in the Dutch media. This was done by analyzing media items from newspapers, television and radio. Additional information came from interviewing experts. It was found that the media mainly emphasize the progress that developments in synthetic biology could bring in the future, while there is barely focus on current developments or applications. The media pay attention to the risks and ethical questions as well, but even though these aspects come forward, there is hardly any elaboration on them. When empowering people for dialogue, there should be more emphasis on current developments and more elaboration on risks and ethics. More different topics should come forward as well and nuances within these topics should be made, so people can get empowered in the best possible way.

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INTRODUCTION

Synthetic biology is a new and rapidly evolving area of research that could draw a lot of attention in the future and has the potential to evoke controversy. In synthetic biology, different DNA parts of different species can be put together to make new structures. An aim in the field is to create completely new DNA structures that are synthesized from scratch, so it is possible to create completely new organisms or to alter existing ones (Benner & Sismour, 2005). In synthetic biology different research fields like biology, ICT, engineering, nanotechnology and biotechnology are combined, pushing biology in a new phase of research (de Vriend, van Est, & Walhout, 2007). Where genetic modification mostly focuses on the alternation of existing organisms, synthetic biology aims to create completely new ones. Instead of 'reading' existing DNA codes, biologists now can 'write' new DNA codes. There is no consensus yet on one definition of synthetic biology, but it was described by the European Commission as follows (SCHER, SCENIHR, & SCCS, 2014):

"Synthetic biology is the application of science, technology and engineering to facilitate and accelerate the design, manufacture and/or modification of genetic materials in living organisms."

When years ago biotechnology was an upcoming field of research, it triggered a diversity of social and ethical questions amongst the public. This caused a gap between scientists and the public, partly due to the top-down implementation of biotechnology, which resulted in general social resistance (Boerwinkel, Swierstra, & Waarlo, 2014). With the upcoming field of synthetic biology, similar social and ethical questions arise. Slowly discussion and dialogue about such questions are emerging not only in the scientific world, but in society as well (van Est, Hanssen, Schenkelaars, Stemerding, & de Vriend, 2013). According to Van Est et al. (2013) the discussion mainly concentrates on the risks that developments within synthetic biology bring on the one side, and the ethical questions about the malleability of life on the other side. Even though the discussions are still mainly led by scientists, it is expected that in the upcoming years it will spread through society, just like the biotechnology debate did in the seventies. Experiences from these earlier discussions, concerning this similar field of research, have taught us a lot about the importance of science communication towards the public. These experiences have shown us that engaging the public into a social debate, and empowering them to do so, is critical while introducing a new technology into society (van Est et al., 2013).

Empowering and engaging people in social debate and open dialogue about synthetic biology is one main goal of the European funded SYNENERGENE project (SYNENERGENE, 2014). To reach this goal it is relevant to know what the current dialogue about synthetic biology is, or more specifically what the current dialogue is in the media. This is important, because media is the main source of information most people have about science (Jarman & McClune, 2007). People use the information they get from the media to form opinions and to create their own scientific views (Carver, 2012). By using different media sources, people can learn to be

critical about real world issues. Real world issues, as often portrayed in the media, are stimulating people to learn and think more about science. In this way, the media is able to empower the people to use their skills in their role as an engaging and responsible citizen (Oliveras, Marquez, & Sanmarti, 2013).

The media can play a role in empowering the public to have dialogue about synthetic biology. Opinions in the media can be dominant though, which in turn can influence views of people (Oliveras et al., 2013). Different media use a variety of frames for their messages, thereby possible affecting the views and opinions of readers. Frames can be defined as "collections of perceptions and thoughts that people use to define a situation, organize information, and determine what is important and what is not" (Kaufman, Elliott, & Shmueli, 2003). By having a dominant frame in a message, the frame can become the basis of a discussion or dialogue, which will cause participants to have a common ground on which conflicts can be discussed. So the frame will determine the direction of the discussion, thus structuring dialogue (Torgersen & Schmidt, 2013). Frames can therefore form a basis for dialogue between people and can be important in the process of critical thinking about synthetic biology in general and in the media.

To stimulate the dialogue, it is thus important to gain more insight in what the current dialogue is in the media, because the media can have a big influence on the public. When there is more insight in the current representation of synthetic biology in the media, more understanding can be developed about the different views that exist and possible future problems can be identified. Such insights can help to empower people in dialogue about this topic.

Therefore this study aims to map to what extent synthetic biology is represented in the Dutch media, in order to gain more insight in how synthetic biology is framed by the Dutch media.

To reach this aim, an explorative descriptive analysis of Dutch media items on synthetic biology will be conducted. Next to this, experts will be interviewed to gain more insight in their views and opinions on how synthetic biology is represented. This can give more understanding about the representation of synthetic biology and it could help to define certain problems that could arise in the future dialogue, based on the current representation.

With this study we hope to achieve an overview on the coverage of synthetic biology in the Dutch media. So far, only a few studies have been conducted on the coverage of synthetic biology in the media, mostly in America and in European countries, but not particularly in the Netherlands. The information resulting from this study can be used to create a foundation for future social dialogue about synthetic biology and it can help to understand why the public responds to different developments within the field in a certain – positive or negative –way. When there is more knowledge about the current representation of synthetic biology in the media, the main topics can be defined and possible problems can be identified.

THEORETICAL FRAMEWORK

Synthetic biology is a rapidly evolving research area with a lot of potential. It is not a research area that stands on its own. Instead it combines different research areas such as biotechnology, nanotechnology, ICT and engineering. The main goal of this field seems to be to have full control of the building blocks of life (Rerimassie & Stemerding, 2014).

Two different styles of synthetic biology can be defined (Andrianantoandro, Basu, Karig, & Weiss, 2006; Benner & Sismour, 2005). The first one is the top-down approach, where organisms are minimized and simplified so their natural systems can be studied. It will thus give an understanding about certain organisms and systems, thereby contributing to the understanding of life. The second approach is the bottom-up approach, in where biologists try to build circuits and systems from nothing by synthesizing new DNA strands. The difference between the two approaches thus lies in the deconstruction and construction of life (de Vriend, 2006).

Applications and expectations of synthetic biology

Synthetic biology could have great influence on developments within healthcare, sustainability and bio-energy (Khalil & Collins, 2010). Researchers working within the field of synthetic biology mainly aim to create certain organisms that do things which they originally cannot do. An example of this is creating a bacteria which is able to produce the precursor of the anti-malaria drug artemisinin. Scientist Keasling and his team were able, by creating this bacteria, to create the drug at a far more efficient and cheaper rate compared to the conventional way, in which the drug comes from a plant (Khalil & Collins, 2010). Researchers create such bacteria by synthesizing strands of DNA which they implement in 'empty' bacteria shells, which are bacteria who have their original DNA removed. The newly created bacteria will then start working according to their new DNA and thus – in this case – will start to produce the precursor of artemisinin.

Another big area where synthetic biology is promising, is in the area of bio-energy. One of the promises is the design of micro-organisms that are able to convert waste into biofuel. Other ideas are to create micro-organisms that can perform artificial photosynthesis or to create micro-organisms that can take carbon dioxide out of the sky and can convert this into something else, such as bio-energy (EASAC, 2011).

Possibilities lay in the creation of biosensors as well, both for inside and outside the human body. Biosensors could, for example, be used to detect insulin levels in the body and react to that in an appropriate way when necessary. Biosensors are not only useful inside the body, as students in the iGem competition showed. The iGem competition stands for 'international Genetically Engineered Machine' competition and teams from all over the world try to design a useful organism by using Bio Bricks ("iGem," 2015). Students from the Dutch team from Groningen University developed a special bacteria, which was altered in such a way that it

can sense if a piece of meat is rotten. When the meat is fresh, the bacteria would be green. When the meat rots it starts to produce certain substances, which would trigger the engineered bacteria to turn red, indicating the meat is not fresh anymore (Brouwers, 2012).

One of the other main aims of researchers is to create completely new organisms from scratch. So far, synthetic biology research is still in an early phase. In 2006 Craig Venter expected that within ten years they would be able to create a completely synthetic eukaryotic cell (de Vriend, 2006). In 2010 Craig Venter and his team were the first ones to create a completely synthetic strand of DNA and were able to implement this in an empty bacteria. The synthetic eukaryotic cell is not yet developed, but it is something that could happen in the near future. When this happens, the possibilities are endless.

Although, a lot of research in synthetic biology is still in the developmental phase, expectations are high. Diseases could be targeted more careful and patient-friendly, the energy we use could become cleaner, the air could become more fresh and all of this would have a positive influence on humans and nature. It almost seems too good to be truth. And when something seems too good to be truth, it probably is. Indeed, there are a lot of social and ethical questions about the research in synthetic biology. All these questions often do not have an immediate answer, and they do not necessarily have a right or wrong answer (Sadler & Zeidler, 2009).

The implications of synthetic biology

The possibilities for synthetic biology are endless. In the previous part different possible applications were explored and those applications are probably going to have great effect on health care and the production of bio-energy. Not everything about synthetic biology is promising though, and as with every new development risks are involved as well. There are so-called hard impacts, which are impacts that can be measured over time (Boerwinkel et al., 2014; Overbeek, Knippels, & Waarlo, 2014). The so-called soft impacts, are impacts that the new technology has on individuals and on society as a whole. Often, these impacts cannot be measured. The hard impacts that come forward with the developments within synthetic biology are mostly about the risks concerning biosafety and biosecurity (EASAC, 2011; Rerimassie & Stemerding, 2012).

Biosafety is mainly about the safety risks for humans and the environment. When working with genetically modified or genetically engineered organisms, there is always a slight chance that the altered organism escapes from the lab into the wild. Genetically modified organisms would then be able to freely grow in the wild, carrying new – possibly bad – traits with them. New traits in the environment could be taken up by native organisms, which would cause these new traits to spread. If the new trait is for example pathogenic, this could be dangerous for different species and could threaten the environment or human beings (Rerimassie & Stemerding, 2012). To avoid such possible disaster, it is important to have certain rules and regulations concerning the research that is done in synthetic biology, so there is little to no chance of organisms escaping into the wild. Another way to secure biosafety is to create the

altered organisms in such a way that they will not be *able* to survive in the wild (EASAC, 2011).

Biosecurity focuses on the aspects of developments within synthetic biology which could be used with bad intensions, on purpose (Rerimassie & Stemerding, 2012). An example of this is the risk of people developing organisms which can be used as biological weapons, such as genetically engineered viruses. Bioterrorist could have the ideas and the means to create such dangerous organisms. This risk could evoke debate about synthetic biology being strictly regulated or being self-governed by the scientific community (EASAC, 2011).

The soft impacts that synthetic biology could have, are mainly about the implications of new research on society or on individuals. Soft impacts are about the questions concerning the impact of innovations on individuals or on specific groups, how an innovation affects a life, and what the innovation means for an individual – or for society's – moral and ethical values (Boerwinkel et al., 2014; Overbeek et al., 2014). Where hard impacts are often about possible physical harm, soft impacts are more about the non-physical harm of innovations. These soft impacts are often neglected in public spheres, while the soft impacts often play a more important role in private spheres, when people talk about innovations and their consequences at home (Boerwinkel et al., 2014).

As discussed, there are a lot of promises for developments within synthetic biology, but there are a lot of questions as well. This could lead to dialogue about all these aspects, not only in the scientific field but in society as well. It is important that people feel empowered to take part in this dialogue and are enabled to have a role as active citizens in the scientific community.

Synthetic biology compared to biotechnology

Synthetic biology may seem like a branch of biotechnology, but in reality it is a research area with other aims and research goals. First of all, synthetic biology is not a research area that stands on its own. As mentioned before, some of the techniques used in other research areas – such as biotechnology, nanotechnology, ICT and engineering – are used in synthetic biology as well. For example, engineering is needed to create new and working DNA strands and systems, while ICT is necessary to test if possible DNA combination could work together.

Synthetic biology does have a lot of similarities to biotechnology, since researchers in both areas try to alter living organisms (EASAC, 2011). There are differences between the two though. Biotechnology mainly focuses on reading and analyzing DNA, and the modification or alteration of biological systems. Synthetic biology differs from this, because it mainly focuses on writing DNA – instead of reading and analyzing it – and it focuses on the designing and building of new biological systems instead of altering existing ones (van Est, de Vriend, & Walhout, 2007). It is thus a different research area with a very different approach.

In other ways the two fields have a lot in common too, since both field try to work with biological systems to improve – or to create – organisms. They both work on the optimization of life. In the past, biotechnology caused a lively debate and since synthetic biology has a lot in common with biotechnology, it is important to look at this debate and possibly learn from it for the future.

The biotechnology debate

In the past a lot of discussion was going on when applications of biotechnology emerged. Controversies around biotechnology mainly erupted in Europe and mostly focused on the risks. There were also a lot of moral objections, concerning stem cell research for example (Torgersen & Schmidt, 2013). There was mainly a lot of aversion to genetically modified food and plants, where the public was concerned about the risks of these products in the wild and the economic interest for large companies. The focus on the risks of biotechnology had a major influence on policy-makers and on the research that was being done at that moment. Because of all the commotion, a lot of research in biotechnology was slowed down or cancelled completely, costing a lot of money. A side effect of these proceedings was that it caused a decrease in the trust the public had towards the research area, causing more debate and more problems for the developments in the field. This together made the research in biotechnology fall into a negative spiral (Boerwinkel et al., 2014; Torgersen & Schmidt, 2013).

Even though synthetic biology and biotechnology are two different areas of research, they also have quite some similarities. Synthetic biology is sometimes called an advanced form of biotechnology. By some organizations, such as the ETC group, synthetic biology is seen as ‘extreme genetic engineering’ (ETC Group, 2007). It is quite logical for people to extrapolate arguments against biotechnology, that were used in earlier debates, against synthetic biology (Torgersen & Schmidt, 2013). This seems to be confirmed by research done on the coverage of synthetic biology in German-language media (Gschmeidler & Seiringer, 2012). In this media, synthetic biology is not perceived very different than biotechnology and it raises the same questions as biotechnology did in the past.

Scientists seem to have learned from the controversies around biotechnology. They seem to acknowledge the importance of involving the public with the implications from their research and to involve them in dialogue about developments, risks and ethics. It is believed that public participation will avoid aversion against the research (Van den Belt, 2009). In the biotechnology debate, the media played a crucial role in how people’s perceptions on biotechnology – and genetically modified food and plants in particular – evolved, since the media payed a lot of attention to this. People picked up on this through media and this was crucial in shaping people’s perceptions. Therefore it is important to understand the role the media plays in the opinions and viewpoints of the public, since the impact of the media on the public can be enormous

The importance of the media

Media is an important source of scientific information for the public. People mostly learn about new scientific discoveries or scientific developments through items made by journalists, such as newspaper articles, radio – or television programs (Pauwels, Lovell, & Rouge, 2012). Transfer of knowledge through media seems to be playing a bigger role over the last years (Jarman & McClune, 2007). Getting scientific information through the media continues to go on for the rest of peoples' adult lives (Oliveras et al., 2013). Therefore, media plays a big role in the uptake of science information by the public and can influence what people learn about science and how they perceive science. This seemed to be the case in the biotechnology debate, where the media mainly focused on the risks from genetically modified food and plants.

A better understanding of how media influences the process of learning about science is important, because media could shape the perceptions people have in general, or could shape views on scientific developments and on new discoveries (Carver, 2012). The media does not necessarily tell the people *what* they should think about certain scientific subjects, but they are sure able to lead the public in a direction of what to think *about* (Pauwels et al., 2012). When media shape news in a certain way, they have the power to shape the meaning it has for the public. This is because media could influence people's understanding and people could use this information to form opinions and to generate their own scientific views (Carver, 2012; Oliveras et al., 2013). Schools have started to realize that media is an important source of scientific information for their pupils as well, also in their later lives as adults. 'Media literacy' becomes more important in education, where students are taught to be critical about science in the media (Jarman & McClune, 2007). People learn to read a text and use prior knowledge to construct new knowledge, opinions or point of views (Oliveras et al., 2013).

According to Jarman and McClune (2010) there are several issues that arise when scientific messages are handed over to the public by the media. These are issues that could have a great influence on the perception that the public has of scientific subjects, and issues that the public should be aware about when involving with these media. To be able to be critical towards news messages, people need to develop some media awareness (Oliveras et al., 2013). There are five themes in media that could influence the public's views and opinions (McClune & Jarman, 2010).

1. *The prevalence of science in the media*: People have to be aware that the media does not give a complete picture of what is really going on in a specific research area.
2. *The nature of science in the media*: People have to be aware that the reporting of scientific news is a process and the results come from selection and construction.
3. *The practices of journalists*: People have to be aware that journalists work within certain boundaries and follow certain rules.
4. *The value of scientific news*: People have to be aware that all media have different point of views that originate from different involved parties.
5. *News perception*: People have to be aware that making science meaningful for themselves is an active process and that they might need to seek other sources of information.

Taking everything into account, including the past biotechnology debate, it is not unlikely that the media could have a large impact on the opinion forming on synthetic biology. In earlier research (Kronberger, Holtz, & Wagner, 2012) it became clear that the media could have an influence on peoples' views and opinions about synthetic biology, but that this did not necessarily mean their attitudes became more supportive. It is not necessarily a goal to make people more supportive of synthetic biology, but people should get motivated to be more involved in dialogue or should be motivated to get more informed about the topic in general. The media could make the public more aware of synthetic biology in general, since it seems that relatively few people have heard about the research field (European Commission, 2010).

Kronberger et al. (2012) state that media could involve people in deliberation on attitudes towards synthetic biology, which could stimulate critical thinking, active citizenship (by being more politically aware and acting on it) and reflective judgement. The study (Kronberger et al., 2012) showed that discussing synthetic biology in a group made people more certain of their views and opinions but this did not mean people were more positive or negative about synthetic biology (Kronberger et al., 2012). It is interesting though that the research showed that high-involvement groups developed more extreme views after group discussions. The high-involvement group with students and the high-involvement group with people who had economic interest became more positive towards synthetic biology, while the high-involvement religious groups and high-involvement environmental NGO groups became more negative. This research shows that the media does not necessarily change the public's *views* on synthetic biology in a positive way, but it does show that using media in group discussions could have impact on opinion forming and point of views.

When there is more knowledge about the current representation of synthetic biology in the Dutch media, certain main topics could be identified and possible future problems for the dialogue could be determined as well.

Synthetic biology in the media: other countries

The representation of synthetic biology in the media has been studied before. These studied were never done on Dutch media though, but concerned other countries and media in other languages than Dutch. These studies give some insight in how the media portrays synthetic biology.

Gschmeidler and Seiringer (2012) looked at the coverage of synthetic biology in the German-language media. They found 233 articles from 2004 to 2009, with the most articles about synthetic biology being published in 2008. It is striking that the term 'synthetic biology' is mentioned in only 65% of the articles, while the other 35% of the articles clearly are about synthetic biology, but they do not mention the term explicitly. In these cases, synthetic biology is not yet seen as a completely different field of research. It was also found that the possible benefits of new developments were mentioned more than the possible risks (found in respectively 83% and 51% of all the articles). The benefits and risks that came forward

though, seemed to be quite similar to those that were presented in the debates around biotechnology. Synthetic biology might not yet get enormous coverage by the media, but so far nothing bad in the research field has happened yet and thus there is not much to write about in the papers, except for some positive developments now and then (Gschmeidler & Seiringer, 2012). Media mostly start to write about hazards and risks only after certain events that happened which caused those (Singer & Endreny, 1994). Gschmeidler and Seiringer (2012) conclude that so far, different types of messages appear in the media that are quite ambivalent. There seems to be no special focus on either the benefits or risks just yet and the dialogue about synthetic biology appears to develop more calmly than was the case with biotechnology.

Cserer and Seiringer (2009) looked into the representation of synthetic biology in the German-language media as well, taking 182 articles into account that were published from 2004 to 2008. They found, contrary to Gschmeidler and Seiringer later on (2012) that synthetic biology was viewed by the media as a very new scientific research field. In these media articles, the possible benefits of synthetic biology were explored more often than the possible risks, which is similar to the findings of Gschmeidler and Seiringer (2012). What came forward in this rstudy (Cserer & Seiringer, 2009) was that when looking at the possible benefits, the media focused mostly on future benefits and not on things that already had been developed. Cserer and Seiringer (2009) also interviewed scientists, who were more critical towards synthetic biology and these scientists found the potential risks (biosafety and biosecurity) something the public should be more aware of.

Pauwels et al. (2012) looked at the trends in American and European press coverage of synthetic biology over the years 2008 until 2011 t al., 2012). In this period of time, 233 news articles were found in the American press and 729 were found in newspapers in the European Union. The coverage on synthetic biology was mostly driven by new discoveries, such as when Craig Venter inserted self-made DNA in an empty bacteria in 2008. In this year there was a peak in the number of press articles, especially in the United Stated but in the European Union as well. This shows that media rather focus on certain events that happened, and not so much on other issues or the research field in general (Singer & Endreny, 1994). The research of Pauwels et al. (2012) focused on certain framing keywords in the newspaper articles. It was found that in both America and in European countries, the words ‘artificial’ and ‘natural’ were words used a lot. This is not a strange thing, since synthetic biology may raise questions about the fine lines between natural living organisms and engineered ones. Next to this, the European press coverage on synthetic biology between 2008 and 2011 was balanced when looking at the subjects that were written about. Of all the articles, 35% focused on the potential benefits of synthetic biology, 33% focused on the potential risks and 31% focused on both of them (Pauwels et al., 2012). Risks concerning biosafety and biosecurity are mentioned in nearly the same ratio and also ethics seem to be of concern in the European press, more than in the American press. The benefits that came forward the most were the potential benefits for bio-energy and those for health care (Pauwels et al., 2012).

All in all, there has been some research on the coverage on synthetic biology in the media, mainly newspaper articles. What comes forward is that there is an emphasis on the potential benefits synthetic biology could bring. The potential benefits that are written about are mostly concerning health care and the production of bio-energy. Another focus in the written media is on the possible risks that come with the research area. The main focus here is on the risks concerning biosafety and biosecurity. In the research of Cserer and Seiringer (2009) experts believed that there was not enough attention in the media for these risks and the experts believed the public should become more aware of the possible risks. In the European press, there is also an uptake in newspaper articles that expatiate on the ethics involved. It is evident that the media gives people certain perceptions and field of visions concerning synthetic biology, which is a process known as 'framing'.

Framing of messages

Framing can help people to make sense of complex information. It can help to organize information in different categories and therefore it can help to give boundaries to dialogue or to give a basis for discussion (Kaufman et al., 2003). As Kaufman et al. (2003) put it: "Frames provide meaning through selective simplification, by filtering people's perceptions and providing them with a field of vision for a problem".
Frames can thus be very useful in dialogue. It can help shape the dialogue, give direction or give focus to it. Framing can also help us to understand the perception of others and it can help to give a better understanding and new insights in the discussion.

Media always use different kind of frames to bring forward a certain message or perspective. A certain type of framing can lead to exclusion of other perspectives, but as said before, it can also help to understand the framed perception better and give direction for dialogue. It is widely accepted though, that framing of messages by the media can greatly affect public attitudes towards these issues (Boydstun, Gross, Resnik, & Smith, 2013; Kaufman et al., 2003). It is difficult to communicate to the public all the different frames and not all those frames will be of interest. It is important though that people are aware that media can use certain frames, or perspectives, and in this way can have an influence on their own opinions. This will lead to more media literacy. It is important to create an awareness that there is more to think about than only that what the media write about. The media can have a large influence on opinion forming and point of views (Jarman & McClune, 2007).

In dialogue or debate, frames are necessary, because without them it is nearly impossible to discuss something (Torgersen & Schmidt, 2013). Frames give common ground and the type of argumentation is dependent on the frame that is dominant. If there is no frame, people could talk about completely different things and not really hear or understand each other. A frame decides the discourse of a discussion or dialogue (Kaufman et al., 2003; Torgersen & Schmidt, 2013). All in all, there are positive influences that framed media messages could have, but also negative ones. A summary of these positive and negative influences can be seen in table 1 below.

Positive influences	Negative influences
Frames can provide meaning by filtering perceptions and giving a field of vision.	Frames can lead to ignorance or indifference to other frames/perspectives.
Frames can give direction to a dialogue or debate.	Frames can influence opinions or points of view.
Frames can help to understand other perceptions better.	Frames can let people interpret one perspective in different ways.

Table 1: An overview of the positive and negative influences framing can have on people.

The media and the way they frame their messages can thus have great influence on the viewpoints of the public and their process of opinion forming. The messages and how they are framed could also form a basis for discussion or dialogue.

The current study

As stated in the introduction, this study aims to map to what extent synthetic biology is represented in the Dutch media. Media can greatly influence the involvement and interest of people, but it can also greatly influence the opinions and views people have on synthetic biology – as was the case with biotechnology. Therefore, in the first place, it is important to understand how the media represent synthetic biology. This research could lead to more insight in the main topics that are represented and it could define possible problems in future dialogue. When it becomes clear how synthetic biology is represented in the Dutch media, which can greatly influence the public, this information could be used to empower people in social debate and it could be used to empower them to become active citizens in the scientific community.

Research aim and question

Synthetic biology is an emerging field of research that may have an impact on society and can raise ethical and societal questions. To be able to foster public dialogue on synthetic biology – as is the aim of the SYNENERGENE project – we first want to know what the current dialogue on synthetic biology is. Considering the role of the media, which can form people's opinions and influence their point of views, it is of importance to learn how synthetic biology is represented in the Dutch media. Therefore, this study will look at the dialogue that is taking place in media.

When we map to what extent synthetic biology is represented in the Dutch media and gain more insight in how synthetic biology is framed, this information could be used to gain more knowledge and understanding on the different views about synthetic biology. Furthermore, the information gained from this study could be used to pinpoint problems, and possible future problems, that arise within the dialogue. This all could help in empowering people in informed dialogue about synthetic biology in the future.

Therefore, the research question of this study is: "How is synthetic biology represented in the Dutch media?"

METHODS

The aim of this research is to map the current dialogue about synthetic biology in the Dutch media by analyzing which frames the media use. In order to reach this aim, an explorative descriptive analysis will be conducted. Experts on synthetic biology were interviewed to gain insight in their views on how synthetic biology is represented. The methods section will explain how we worked towards the research aim.

Data sources

Different data sources were used for the media analysis. The data for the analysis included newspaper articles, television – and radio programs. It was decided to use material that was found in Dutch media only. This would give the best overview of the representation of synthetic biology in the Netherlands. The three data sources are sources that all Dutch people have access to and therefore it is most likely that the Dutch people read, see or hear about synthetic biology through these forms of mass media.

Newspaper articles

A search in LexisNexis was conducted, which is an online newspaper archive which contains all Dutch coverage in the national and local newspapers on synthetic biology. The search term used was "synthetische biologie", which is synthetic biology in Dutch. In march 2015 this resulted in 249 hits of which 177 hits were original newspaper articles. This means these articles were not duplicated in any other form of media that is available in LexisNexis. The first article in the media about the subject appeared in 2007, meaning there is a coverage of nine years. Of every year until 2015, ten articles were selected. This gives a total of ninety newspaper articles about synthetic biology, so 51% of the 177 articles were analyzed.

The ten articles per year were chosen by scanning through all of the articles of a specific year. Some of the articles only mentioned synthetic biology shortly, meaning these did not focus on synthetic biology in any part of the piece. An example of this is when synthetic biology was mentioned as a new development, but there was no elaboration on the subject at all. Out of the remaining articles a total of 90 articles were randomly selected. The articles that were used for this research can be seen in Appendix IV.

Television programs

Dutch broadcasting networks were searched for programs that focused on synthetic biology. Since there is no complete database for all Dutch broadcasting networks, a variety of television network websites were searched. A list of these networks can be found in Appendix III.

The websites of these television broadcasters have search options. To find data sources the search term "synthetische biologie" was used. At the end of the search a total of 5 videos were

obtained. All of these videos were used in the analysis. The television programs used can be seen in Appendix V.

Radio programs

The national radio broadcasters were searched for relevant programs as well. Comparable to the television broadcasters, there is no existing database for radio networks, so the websites of the national radio broadcasting networks were searched to find hits on synthetic biology. The term "synthetische biologie" was used and this resulted in a total of 14 radio fragments. All fragments were used for analysis. The radio programs used can be seen in Appendix V.

Coding system

The coding was set up according to seven earlier developed media frames by Overbeek et al. (2014) based on Nisbet and Lewenstein (2002), Kaufman, Elliott and Shmueli (2003), and Carver (2012). Overbeek et al. (2014) propose seven media frames that can be applied to technological innovations. Table 2 shows these frames, which were used in this study.

Media frames	**Description/questions**
Progress	What can the innovation bring in terms of progress? Does this have any negative aspects? Progress can be prosperity, welfare, doing good or it can be about preventing damage.
Economical	What can the innovation bring in terms of economic progress? Does this give any benefits to people or society? Or does the innovation has a negative influence on the economics?
Ethical	Is the innovation responsible in terms of ethics? Are ethical principles concerned? What are the boundaries? What are possible consequences of accepting – or *not* accepting – the innovation?
Risks	What risks does the innovation bring? Are these risks *hard impacts*, where the innovation has measurable consequences, or *soft impacts*, where the consequences cannot be measured. Hard impacts can be about bio-safety and bio-security, or possibly unknown risks. Soft impacts can be about the influences of the innovation on persons or society.
Nature-nurture	Does the innovation has any influence on nature-nurture? Does it, for example, influence the environment or genetic variation?
Laws and regulation	Who controls the innovation? Who regulates it? Who makes the rules? Does the public has any influence on the regulation, are they responsible for it? Are different stakeholders involved?
Globalization	What are the consequences of the innovation worldwide? Do third world countries profit from it? Does our own country benefit from it?

Table 2: Media frames for technological innovations (Overbeek et al., 2014).

The frames do not exclude each other. Some frames have aspects in common. An example of this is the connection between the progress frame and the economics frame, since progress due to a new innovation could potentially bring economic benefits. Therefore it is hard to make an absolute distinction between the frames, because some of the frames are closely related.

The media items (n=109) were coded by searching for quotes, sentences and/or fragments that could be placed in one of the frames. Some of these fragments that were coded, could be placed within more than one frame. This means that one fragment could have more than one code attached to it.

During the coding process sub-codes for sub-frames were created, since specific subjects were used frequently by the media. These sub-frames were created to give more insight in specific topics within a main frame the media focused on. For example, the media frequently used the development of new medicine to explain applications of synthetic biology which is part of the 'progress' frame with the sub-code of 'medication' (P-M). A full list of codes, sub-codes and their descriptions can be found in Appendix I.

The program Atlas.ti versions 6 and 7 were used for coding.

Next to the media framing codes, two other codes were used to analyze the material. The first code was SD which stands for 'social debate'. Some of the material emphasized the need for a social debate about synthetic biology, for example a debate about the risks and ethics. The second code was I for "iGem", which is an international competition in synthetic biology for teams who can use Bio Bricks to create something new or innovative. These codes do not specifically stand for any kind of frame, but these two subjects were notably present in a substantial amount of media items, which is why it was decided to make special codes.

Interrater reliability

After coding the media items, 20% of the newspaper articles (18 articles) and 31% of the television – and radio programs (6 shows and fragments) were coded by a second independent coder to ensure reliability. Both the first and second coder worked independently. The materials that were coded by the second coder were randomly selected. The second coder received the descriptions of the codes and instructions for coding, see Appendix II.

The second coder received the complete media items with the fragments, that were coded by the first coder, highlighted. These were the parts that the second coder had to code as well, but the second coder was instructed to look through the complete media items to ensure there were no parts missed. If one fragment had more than one code attached to it, as coded by the first coder, this was made clear to the second coder by putting the number of attached codes behind the fragment. The second coder could then decide to attach more codes to that fragment or not. This was discussed afterwards.

The second coder coded the fragments within sub-frames when possible, but in the end – for the calculation of the interrater reliability – everything was put in the main frames. So for example, when the second coder coded a fragment into the P-M sub-frame, this was counted as a code within the progress main frame (P). This was done, because the sub-frames were only created to gain more insight into the different topics that the media focused on within their main focus – or within their main frames.

Afterwards, a conversation between the two researchers followed. Differences in coding were discussed and fragments were possibly changed to a frame both researchers agreed on. This conversation between researchers led to intersubjective agreement and led to definite decisions in the coding.

Interviewing experts

In addition to the media analysis, interviews were held with experts on ethical issues and on stimulating social dialogue about science. By interviewing these experts, we hoped to gain more insight in their views on the current representation of synthetic biology in the media. The experts could share their views on the different frames and could tell which frames, in their opinions, are important to come forward in the media and why. Next to this, these interviews could shed some light on what the experts hope the media could achieve by bringing synthetic biology in the news. This can give more knowledge on the current representation of synthetic biology in the media and on the possible issues in the future.

In these interviews, the results of the media analysis were brought forward, so that the experts could give their opinions and thoughts about the current representation of synthetic biology in the media. In addition, they could share if they thought some subjects – or frames – were missing.

The complete list of questions for the interviews can be found in Appendix VI.

For this research, three experts were interviewed:

- Mr. Drs. Virgil Rerimassie: Employee at the Rathenau Institute. His research focuses on the ethical, social and legal aspects of upcoming science and technology areas, mainly synthetic biology. Stimulating dialogue about these new research areas is an important focus.
- Huib de Vriend: Is involved in the social debate about biotechnology since 1985. Owns the company LIS Consult in which he advices several parties about social and ethical aspects of the life sciences. He explores new technologies and developments, also within synthetic biology, and looks at the possible social impacts.
- Michelle Post: Was the policy and practice manager of the iGem team of the TU Delft in 2015 and won the overall competition together with her team.

Mr. Drs. Virgil Rerimassie and Michelle Post were interviewed together, while Huib de Vriend was interviewed individually. These were face-to-face semi-structured interviews

which lasted for about an hour. The interviews were audio-recorded. Afterwards the interviews were transcribed. The transcribed text was matched with the interview questions, meaning that questions and answers were put together, because sometimes an answer to a question was given later on in the interview or the expert came back on the subject. Subsequently the answers matched to the specific questions were used for analysis.

RESULTS

The results from the media analysis can be found in the first part of this section. In the second part, the interviews held with experts on synthetic biology will be discussed.

Media analysis

Ninety Dutch newspaper articles, 5 television programs and 14 radio programs were coded according to the methods described earlier in this paper. This analysis will give an overview of how the media framed synthetic biology over the past years, which will give us insight in how the debate on synthetic biology evolved and what are important factors that the media discuss.

Table 3 below shows the overall results of the analysis of all the materials. In this table, the results of the analysis of the newspaper articles and the television – and radio programs were all put together, since there was barely any difference in how these different media sources represented synthetic biology. There was thus barely any difference in how synthetic biology was framed.

After coding, 20% of the newspaper articles (18 articles) and 31% of the television shows and radio fragments (6 shows and fragments) were coded by a second independent coder to ensure reliability. The interrater reliability between the two coders for the newspaper articles was 90,9%, while the interrater reliability for the television shows and radio fragments was 86,2%. The average – and thus total – interrater reliability for the complete media analysis is 88,6%. Since the sub-frames were developed to recognize different themes and topics within each main frame, it is most important to calculate the percentage of agreement within the main frames. Everything that was coded by the second coder in a sub-frame counted for that specific main frame for interrater reliability.

In the results section, different quotes from media items are used to show how the coding process went and to give some examples. The codes behind these quotes refer to where the fragments can be found in the coding file in Atlas.ti.

Frames	Number of quotes in frames (% of total)	Sub-frames (codes)	Number of quotes in sub-frames (% of total)
Economics	71 (6,9)	Economics (Ec)	12 (1,2)
		Investment (Ec-I)	22 (2,1)
		Patent (Ec-P)	23 (2,2)
		Progress (Ec-Pr)	14 (1,4)
Ethics	130 (12,6)	Ethics (Et)	59 (5,7)
		Boundaries (Et-B)	30 (2,9)
		Playing God (Et-G)	20 (2)
		Perfect humans (Et-PH)	21 (2)
Globalization	12 (1,2)	Globalization (G)	12 (1,2)
Nature-Nurture	7 (0,7)	Nature-Nurture (NN)	7 (0,7)
Risk	164 (15,9)	Risk (R)	66 (6,4)
		Criticism (R-C)	47 (4,6)
		Escape in wild (R-E)	23 (2,2)
		Weapons (R-W)	28 (2,7)
Progress	615 (59,9)	Progress (P)	134 (13)
		Biosensors (P-B)	31 (3)
		Carbon dioxide (P-C)	16 (1,6)
		Criticism (P-Cr)	40 (3,9)
		Craig Venter (P-CV)	43 (4,2)
		Energy (P-E)	88 (8,6)
		Creating life (P-L)	37 (3,6)
		Improvement (P-I)	96 (9,3)
		Medication (P-M)	130 (12,7)
Laws & Regulation	29 (2,8)	Laws & Regulation (LR)	29 (2,8)
iGem*	25*	iGem (I)*	25*
Social debate*	37*	Social debate (SD)*	37*
TOTAL	1028 (100%)		1028 (100%)

Table 3: Overall results of the coding of all the media material (n=109) sorted by frames and sub-frames. *The results for the I and SD code were not included, since they do not represent a frame.

* The coding for iGem (I) and social debate (SD) are visible in table 3, but did not contribute to the total number of codes, since these codes did not represent a frame. They were added to give more insight in how much the iGem competition was mentioned and how much the importance of social debate was mentioned.

The first column shows the main frames that were being used for the analysis. The second column shows the number of times every frame was coded in all of the material used (n=109). In the same column it is shown for every frame how much it was coded, in percentages of the total number of codings. The third column gives an oversight of the sub-frames and their codes. Behind that, in the last column, the number of times every sub-frame was coded for is shown, together with the percentage these sub-frames were coded compared to the total number of codings in parenthesis.

Table 3 shows that the frame of progress is used the most on average in all material analyzed. Of the 1028 codes, 615 were progress-codes (59,9%). The two other frames that were used the most, were those of risk with an overall coding of 15,9% and that of ethics with an overall coding of 12,6%. The economics frame was coded in 6,9% of all of the cases, while the frames for globalization, nature-nurture and laws & regulation were used less frequently.

Below, the results will be discussed in more detail where there will be a focus on every main frame. In table 3 above, the percentages of every sub-frame within the total amount of codings is shown, but the percentages of every sub-frame *within* a certain main frame are calculated as well. This will give insight in the subjects that most often come forward in a main frame. These percentages are shown in the figures in the results below.

Progress

In most of the coverage on synthetic biology in the media, at some point there is a focus on the progress that synthetic biology will possibly bring or already brought. Of all the frames, this one is used in 59,9% of all of the cases. Progress is about applications that already exist or about applications that can be expected in the near future. Examples of this are the anti-malaria drug or the possible future applications in bio-energy. The next quote, for example, focused on the anti-malaria drug and was therefore coded within the progress frame – and in the 'medicine' sub-frame.

"The American researcher Jay Keasling managed to build in some genes in existing bacteria, so now these bacteria are able to produce artemisinic acid, which is a precursor of an anti-malaria drug that normally gets isolated out of plants, a difficult process." (P10-#3)

Another example is the next quote, which is about the applications of synthetic biology within the production of bio-energy.

"Synthetic algae are going to convert sunlight, carbon dioxide and water into oil from which we can produce diesel and kerosene (...). This is going to be big." (P21-#7)

These are examples that clearly belong in the progress frame, since they emphasize the practical use of synthetic biology. As can be seen in table 3, most of the codes in the progress frame are about medication (12,7% of the total number of codings) and clean energy (8,6%), while overall 13% of the codes fall into the general progress frame. This frame was used when a fragment did not fit any sub-frame, or when any form of progress was just mentioned

in general. An example of a fragment that was coded into the general progress (P) frame is shown below.

"Synthetic biology also offers a more fundamental scientific promise: the knowledge it can bring about the biological basis and possibly about the origin of life." (P9-#9)

In figure 1 below it is shown in percentages how much every progress sub-frame was used within the progress main frame.

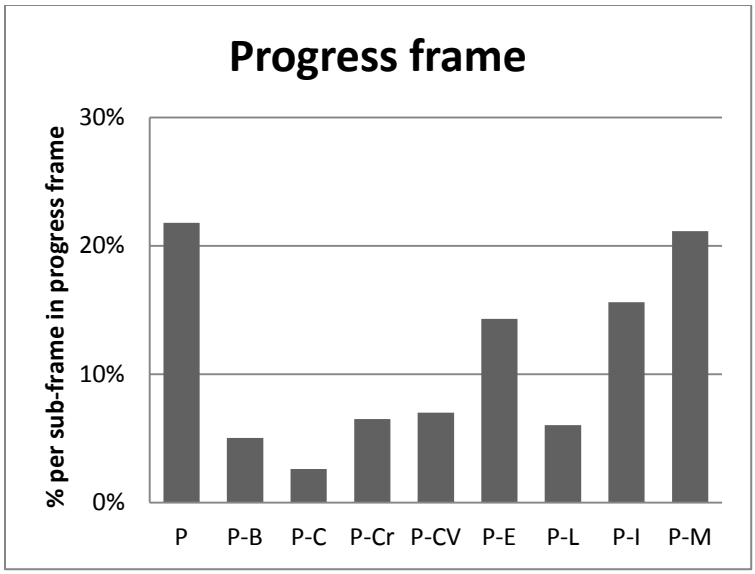

Figure 1: The use of sub-frames within the progress main frame.

Figure 1 makes it clear that the topics concerning progress most discussed in the media items are progress in general (P 21,8%), the developmental possibilities within bio-energy and medication (P-E 14,3% and P-M 21,1%, respectively) and improvements scientists would be able to make on humans, plants and other life forms (P-I 15,6%).

Achievements of Craig Venter and his institute are mentioned in numerous media items as well (P-CV 7% within the progress frame, see figure 1). Craig Venter was the first to delete the original genome from a bacteria species to replace it with another, minimal, genome. Even though this achievement does not bring forward any specific kind of application yet, it is something that puts emphasis on the progress that is being made within synthetic biology. The code P-Cr, which is about the critique on progress within synthetic biology, makes up 6,5% of all of the progress codings (figure 1). An example of the critique that is given, is on Craig Venter's innovations. Venter often says that putting a minimal genome into an empty bacteria is the start of creating new life from scratch, while critiques say he technically did not create life, since Venter used already existing DNA instead of creating a genome from scratch. The fragment below is an example of a fragment that was coded within the critique sub-frame (P-Cr).

"Critici say: Venter is a very smart man, maybe even brilliant, but what he does has nothing to do with creating life. The DNA is synthetic, but the cell is not." (P21-#2)

The work that Venter and Keasling have done within the field of synthetic biology are a few examples of developments that occurred at the time the media focused on it, while most of the other media items emphasize the possible future developments within synthetic biology, such as developments and promises within the medication field or the bio-energy field. This is not a strange thing, since there are currently hardly any specific or ground-breaking applications that originated from synthetic biology.

Risk

Another frame that is used a lot in the media, is the risk frame (15,9% overall). In figure 2 below it is shown in percentages how much every risk sub-frame was used within the risk main frame.

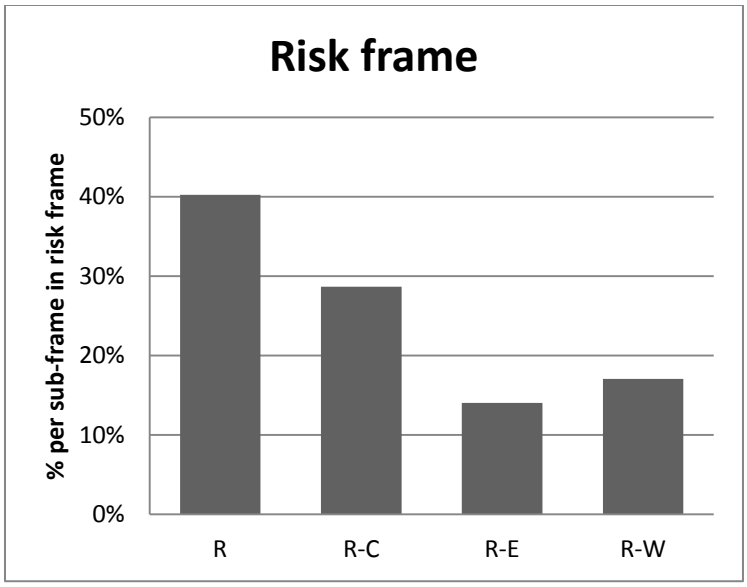

Figure 2: The use of sub-frames within the risk main frame.

There are some risks that are mentioned the most in the different media. One of them is how synthetic biology can be used by terrorists to create a biological weapon (R-W, 2,7% of total and 17,1% within the risk frame). An example fragment that was coded this way can be seen below:

"One potential disaster of the developments within synthetic biology, is that someone could consciously develop a disease that could destroy the human race." (P89-#1)

Another one is the risk of an organism escaping and surviving in nature, where it could spread and kill, or mutate and cause damage (R-E, 14% of the risk frame, figure 2).

As can be seen in figure 2, 40,2% of the codings that are within the risk frame are coded within the risk frame in general (R). This means that in the media the possible risks synthetic

biology brings are mentioned in general, or specific risks are mentioned that are not often used. This high percentage shows that even though the risks are mentioned, there is hardly any elaboration on it.

A lot of the risks brought up are criticized by scientists or other people involved (R-C, 28,7%, figure 2). In these cases, the media often say terrorists have easier options than the use of synthetic biology to create a weapon. When talking about the risk of a synthetic organism escaping from a lab, it is often said that these organisms exist of a minimum set of genes, which will make it very unlikely that they will be able to survive in the wild. An example of a fragment of this below:

"They can only survive in the ideal circumstances of a lab. In the outside world they will quickly die, because they hardly possess any genes which they can use to adapt to their environment." (P2-#8)

Thus, risks of synthetic biology are certainly mentioned, but in a lot of cases the risks are minimized and criticized.

Ethics

As can be seen in table 3, of all of the codings, 12,6% were coded within the ethics frame.In figure 3 below it is shown in percentages how much every ethics sub-frame was used within the ethics main frame.

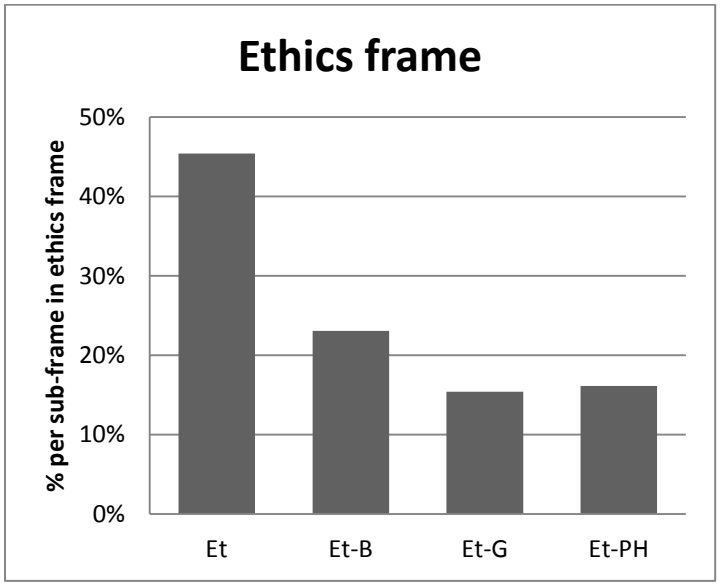

Figure 3: The use of sub-frames within the ethics main frame.

Figure 3 shows that the general ethics sub-frame (Et) was used in 45,4% of the codings within the ethics frame. This general code was used when the ethics were mentioned shortly, or when it could not be coded otherwise, but this shows that often the media items do not go deeper into the ethics questions that exist in this field. It is striking how little the media items go into the ethics around synthetic biology. Especially since when biotechnology was emerging and

evolving, the ethics surrounding this field were actively explored and discussed, also in the media. In a lot of the media items about synthetic biology, it is said that people should think about the ethics that are involved with synthetic biology and discuss them, but often this is not the main point of item and there is no elaboration on ethical issues.

Like the risk frame, the ethics frame is thus often mentioned shortly, somewhat as a side note that belongs with synthetic biology. When the ethics frame comes forward in the media, it sometimes is about creating life in general, playing God (Et-G) or improving mankind to create the perfect human (Et-PH). It is often discussed that we should think about our boundaries in science (Et-B). The next fragment shows ethical questions concerning the boundaries and how humans play God.

"Some people fear that we play God or that we violate human dignity. Other fear a slide: what are the boundaries, and how can we guard those boundaries?" (P14-#2)

It is noticeable that in 2007 the Rathenau Instituut published a report about synthetic biology, where they tried to stimulate public debate about the risks and ethics. The items in the years 2007 and 2008 often mention this report and emphasize that public dialogue is necessary to talk about the risks and ethics concerning synthetic biology.

Furthermore, when talking about ethics and risks, synthetic biology is in some media items compared to biotechnology and the author of an item claims that the discussion about ethics and risks is already held when biotechnology emerged, and therefore we don't need a new view on the ethics and risks of synthetic biology.

Economics

The other frames are used, but less frequent than the progress, ethics and risk frames. At first, we have the economics frame. What is mainly mentioned in the media items is that Craig Venter has patent on his new bacteria (Ec-P) or that a company invested millions of dollars in research (Et-I). BP for example, invested millions to research a bacteria that could create biofuel.

"Companies have high expectations as well. Oil company BP invests 500 million euro in research to synthetic organisms that could create biofuel." (P4-#4)

In figure 4 below it is shown in percentages how much every economics sub-frame was used within the economics main frame.

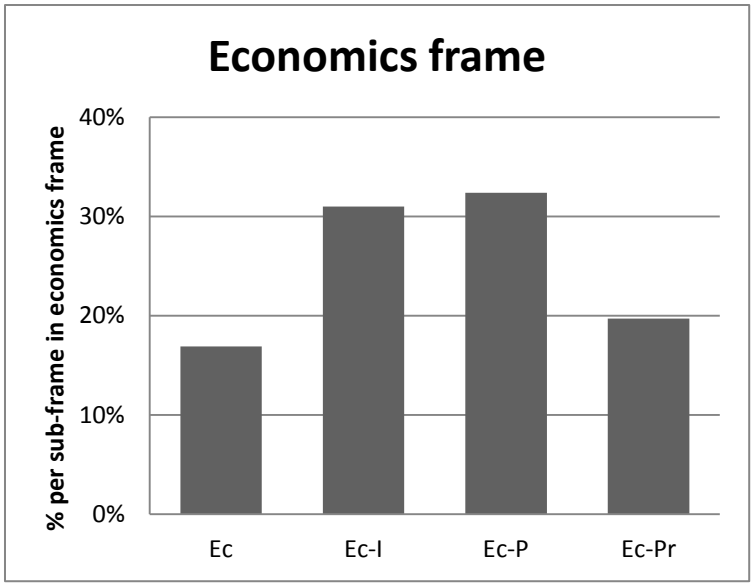

Figure 4: The use of sub-frames within the economics main frame.

Sometimes the ethics and economics frame combine, when the question is raised if it possible to have a 'patent on life', as Craig Venter has a patent on his new bacteria.

"But can you patent all these different modules? A lot of them just exist in nature. It is a fundamental discussion where the opinions differ." (P81-#3)

As can be seen in figure 4 above, the sub-codes of investments and patents are used most within the economics frame, with 31% and 32,4% respectively.

Law and regulation

The law – and regulation frame is sometimes used. Often it is emphasized there are already rules or laws concerning genetically engineered organisms – and that they apply on synthetic biology as well, as the next fragment shows:

"The current rules for biosafety are probably sufficient, Plasterk thinks (...)." (P1-#18)

But in some cases, there are concerns as well, even though there are hardly any media items that elaborate on such concerns. Here is an example of why it could be important to think about how laws and regulations may have to change in the future:

"When bodily functions can be read from a distance – for example when blood values are being send with a RFID nanochip – where does this information legally belongs to?" (P14-#12)

It is also said that the government should monitor progress in synthetic biology closely and restrict it when something goes wrong, or create new laws when necessary. Of all of the fragments, 2,8% was coded in the law & regulation frame. This frame did not need any sub-frames, since there were hardly any different topics within the law & regulation main frame.

Globalization and nature-nurture

The globalization and nature-nurture frames are the least found frames in the media, being used 1,2% and 0,7%, respectively. When an item mentions the risk of a synthetic organism escaping into nature, it is indirectly implied that such an organism could endanger or alter organisms as they are now, thus have an impact on genetic variation (the nature-nurture frame). In other cases, the author brings forward that synthetic biology could be used to create the perfect human being, which also indirectly implies that genetic variation amongst humans is altered. Most of the times though, these nature-nurture implications are not mentioned explicitly and it is more framed as a risk or an ethical affair. An example of how the nature-nurture frame came forward can be seen below. This shows how synthetic biology could lead, for instance, to a new balance between natural and synthetic.

"But Heijnen still wants to give natural evolution a place. A cell can balance its newly acquired chemical routes with its own natural routes and improve itself." (P3-#7)

When looking at the globalization frame, it is noticeable that the implications that synthetic biology has on the world, on the Netherlands or on third world countries is hardly mentioned. In rare cases, when the anti-malaria drug is described for example, it is mentioned how this could help countries which suffer a lot from malaria. Most of the times, the link to globalization is very indirect or absent as a whole.

As explained in the theoretical framework, there are links between different frames such as the nature-nurture frame and the ethical or risk frames, or between the globalization frame and the economics frame. The frames for globalization and nature-nurture are often not the dominant frames in such cases.

iGem and social debate

In this study, we also looked at how many times the iGem competition was mentioned or how many times the need for social debate was mentioned in the media. This could give more insight in the contexts in which synthetic biology came forward.

What comes forward a lot in the media, is the iGem competition. In some years, Dutch teams joined the competition and sometimes achieved good results with even first places. When this is the case, a lot of the items mention the competition, the Dutch teams and their innovations. When this happens, the media sometimes focus on the progress that is made, and can be made in the future, with synthetic biology. In a lot of cases though, there is an emphasize on the competition part of iGem and the role that the Dutch teams played in this. The fragment below shows this.

"A student team from Delft caught eyes early November in Boston (US) during a student competition in synthetic biology. The students won a gold medal and an award for best weblog." (P55-#2)

The rest of this specific article focused on the competition aspect of iGem. It shortly, in one sentence, told about what the Dutch team developed, but then it elaborated more on how well they did.

As can be seen in table 3, the iGem competition is mentioned 25 times. In the 109 media sources, the importance of social debate (SD) is mentioned 37 times.

Interviews with experts

Three experts on ethical aspects and social dialogue about scientific topics were interviewed to gain more insight in their views on the representation of synthetic biology in the Dutch media. The experts are involved with synthetic biology as well. These experts are Virgil Rerimassie (V), Michelle Post (M) and Huib de Vriend (H).

These experts were interviewed to gain more insight in their views on how synthetic biology is represented in the Dutch media, and to gain insight in which ways they saw synthetic biology was being represented. Furthermore, the experts could share their views on the dominant frames or on which frames they believed should come forward more.

Current representation of synthetic biology in the Dutch media

Overall, the experts see more attention for synthetic biology in the media during the last few years, but there still is not a lot going. Media items about synthetic biology are rare. Michelle Post believes the items are too negative, which are the things people will remember about the research in this field.

M: *"I feel like sometimes the representation is too negative or too frightening. People should get informed about the dangers and risks, but the news should not be too negative, because in general people remember the negative messages instead of the more positive ones. The media has a huge influence on this."*

The media can thus influence the views and opinions people have about synthetic biology, but the media could also get people involved by stimulating people to have dialogue about it. In this the media can form a bridge between scientists and the public.

Even though the media could stimulate dialogue, you cannot tell the media what to write or talk about. Media are mostly interested when something big happens: when there is breakthrough or when something bad happened. That is not the case for synthetic biology yet, which could explain why it is not really out there yet, as Huib de Vriend described.

H: *"Journalists will ask if it is something new, if it is a scientific breakthrough or if it comes to the market. If the answer is no, the media will probably not pick up on it. Synthetic biology is still more of a promise."*

The importance of synthetic biology in the Dutch media

It is important to make connections between science and society. This became clear during the biotechnology debate in the seventies, as described earlier in this paper. The public can have all sorts of questions about ethics and risks and the scientific community should involve people in dialogue about such subjects.

V: *"To reach and inform a larger public, the media are important. Their role as a watchdog is important as well. The media plays a crucial role for the dynamics between society, politics and science."*

Even though the media could play an important role in activating dialogue, that does not really happen yet. Big developments or breakthroughs in synthetic biology did not happen yet. According to Huib de Vriend, biotechnology only became interesting for the media when concrete things started to happen.

H: *"The attention for synthetic biology should be given at the early stages of developments, but this does not happen in the media. With biotechnology it only became interesting for the media when concrete developments like soy started to arrive in the country. Developments should be visible and tangible, that is how it works. We have to wait for great developments, applications, promises or big scandals."*

But the experts believed that the scientific community did learn from what happened with biotechnology:

V: *"Scientists then believed that the public would agree with everything as long as they explained it to them. But that's not the point, the point is that citizens should have a say in the developments. I feel that scientists now really want to listen to society and discuss with them."*

What the media can achieve by giving attention to synthetic biology

The media can form a bridge between the scientific community and the public. By being honest, they can provide the public with information and empower them to be responsible and active citizens, which can have a say in scientific developments as well. By being open, a bond of trust will be developed.

V: *"By being honest, as a scientist to the media, about the developments within society, citizens will reward you with trust. It is a win-win situation."*

Scientists will have to involve the public to create this trust. The media can stimulate this process.

M: *"I often think scientists feel like they are on their own, but they should realize they are a part of a whole. The media can be a bridge between scientists and society."*

About the three biggest frames in this research: progress, risk and ethics

The experts believed that it is important the media pay attention to the progress that synthetic biology brings, or could bring in the future. At present times, the media mainly focus on the possible future applications and developments, which is probably the case because there are no big developments right now. It would be of importance though, that the public would read or see or hear more about current developments within synthetic biology, because that is something that is relevant for now and not something that is far away in the future. People might relate to such things more, which could benefit the social dialogue. It will be hard though, to point out current developments, since such developments are still very abstract for a lot of people.

V: *"I think it is more important to think about the point when concrete applications are being launched into society and what that means."*

The ethical questions and risks that are coming forward, are probably not yet very different from those in biotechnology. This could change in the future though, when more specific applications are developed.

Missing subjects concerning synthetic biology in the Dutch media

The experts all agree on that it is important to closely follow developments within synthetic biology once it comes out of the lab. This is the point that we can start to look at the consequences as well, more concretely, and it can be decided if laws need to change for instance. This is something the media should be critical about, this is where the media could play an important role as a watchdog.

H: *"When looking at law and regulation, it is important to think about new laws when the old ones are not good enough anymore. Synthetic biology is more complex and radical than biotechnology, so at some point the law and regulation has to be reconsidered."*

V: *"I think though, we have to look forward and think about the current laws and regulation. When synthetic biology 'comes out of the lab', everything will become more concrete and at that point you can consider if the laws and regulations are still sufficient. At that point, critical journalists are important as well."*

The experts also believe that there should be more of balance of frames. As came forward out of the media analysis, the media mainly focus on progress, risks and ethics. When synthetic biology starts to become more known, and starts to come out of the lab, other frames could be equally important to emphasize, such as the law & regulation frame as said before.

Balance within frames is important as well. The media should be critical, for instance, about the progress that synthetic biology could bring. They should be critical, because is that kind of progress, progress for everybody or just for a select group of people? These are ethical questions as well. The media should look critically at such questions and they should be able

to look further than just the innovation: what kind of processes does the innovation start, for example? The media could be a watchdog.

H: *"A benefit for one person, is not directly a benefit for every person. When new medicine are created, are those medicine going to be attainable to everybody, for example."*

CONCLUSION

The research question posed in this study was: *"How is synthetic biology represented in the Dutch media?"*. To answer the question, 90 newspaper articles, 5 television programs and 14 radio programs were analyzed (n=109). All these media items were in Dutch. The frames developed by Overbeek et al. (2014) were used for analysis – based on Nisbet and Lewenstein (2002), Kaufman, Elliott and Shmueli (2003), and Carver (2012). Next to this, three experts were interviewed who could give more insight in their views on how synthetic biology is currently represented in the Dutch media.

Media analysis

To make final conclusions, we will first make conclusions based on the representation of some of the main frames. These findings together will form a final conclusion which will answer the research question.

Progress

The frame that was represented the most in all media items, was the progress frame, which covered 59,9% of all the codes. This shows that the media mainly focus on the developments within synthetic biology and what kind of progress this can bring. Of all the fragments that were coded as progress, the majority was about the developments within healthcare. Two other large subjects within the progress main frame were developments in the area of bio-energy and working on improving humans or other organisms.

It is clear that the media above all focus on the possible future improvements that synthetic biology can bring. Often, when the media focus on progress, there are barely any concrete examples of developments, but mostly expectations for the future. The media does not only give attention to future expectations in synthetic biology, it also looks at achievements. In 2007, when the first newspaper articles on synthetic biology emerged, the media mainly focused on the research that was done by Craig Venter and his team. Later, Keasling and his team were able to develop a bacteria that could create the precursor of the anti-malaria drug artemisinin. This was broadly covered in the media.

Overall the media seem to mainly focus on the progress, in a positive way, of synthetic biology. The emphasis is on the possible future developments and the possible use of the research, which means there are often no concrete or existing examples yet. Next to this, the mentioning of synthetic biology by the media is event-driven. When something is achieved within the research field, synthetic biology gets covered in the media. In these cases there are often more concrete examples.

Risk

The risk frame was present in 15,9% of all the codes. Even though the media mentions the risks involved with research in synthetic biology – such as biosafety and biosecurity – the

main focus is not on these hard or soft impacts. The main focus is on the critique on these risks. This means that (mostly) experts explain why it is, for example, unlikely that synthetic biology will be used for bioterrorism. When the media put forward the risks of synthetic biology in any other way, it is – in most cases – not elaborated on.

So we may conclude that synthetic biology in the Dutch media is mainly represented in a positive way, where there is emphasis on the possible future developments and the improvements these developments could bring. There is an awareness of the possible risks, but these risks are often not explored into detail. Soft impacts are hardly mentioned at all. This is in line with the study of Pauwels et al. (2012), where in both American and European press coverage on synthetic biology there was more emphasis on the progress (benefits, they call it) than on the risks as well.

Ethics

The ethics frame is represented in 12,6% in the Dutch media. The ethical questions concerning synthetic biology are not the main focus. This is different from when research in biotechnology started and a lot of attention was given to ethical questions. Even though ethical questions are stated in the media items, these questions often are comparable to the questions asked in the earlier biotechnology debate. The questions are raised, but there is hardly any elaboration on them, and the media does not try to find answers or solutions.

The media does not make a significant difference between the ethical questions raised by synthetic biology and the ethical questions that were raised by biotechnology before. Ethical questions are put forward, but it is rare that these questions are elaborated on. We can thus conclude that there is little concern yet for the ethics involved in synthetic biology.

Other frames

Synthetic biology is hardly framed in the media items in other ways than the three frames discussed above. In 6,9% of the codes the economics frame was used, where the emphasis was on the investments in synthetic biology by big companies, or in the patents that are claimed or could be claimed. For the media, the economical side is not a main perspective yet. The same can be concluded for the representation of the other three frames: law & regulation, nature-nurture and globalization. There is hardly to no attention at all for nature-nurture (0,7%) and globalization (1,2%).

Interviews with experts

The experts believe the representation of synthetic biology in the media could improve. The media should be more critical towards developments and should form a bridge between science and society. The media has a huge influence on what people learn about science and it is important the media gets involved with synthetic biology at an early stage. Then they could inform the public and create discussion, so society gets involved. At present, there is barely attention for synthetic biology because there are few concrete applications. Synthetic biology is a promise for the future, and right now it is not that interesting yet.

Synthetic biology is a big promise and should evoke questions about the risks and ethics. The media can highlight the viewpoints of different stakeholders and can reach a larger public, to inform them and evoke discussion about these point of views. They can get the public to be involved and they can empower them for future dialogue about issues in the field.

Getting the media to pick up on synthetic biology is difficult. According to De Vriend we will have to wait for important developments, new applications, or promises and big scandals. Only then will synthetic biology be interesting for the media and the public. Rerimassie and Post believe that participation of the public is important, but difficult to achieve. There is so much going on in the lives of people, that they first want to see something happen in the research field, before they want to think about it, discuss it or act on it.

Developments within synthetic biology should be followed closely, especially when it comes 'out of the lab'. Then, there is a chance the media will give more attention to synthetic biology. De Vriend emphasizes that the media should balance different frames, because progress for one person does not necessarily mean progress for every person. The media has to look critically at such dilemmas.

Overall

All in all we can conclude that, for synthetic biology, the progress frame is best represented in the Dutch media. Within this main frame, there are several topics that are explored more, such as the developments in healthcare or bio-energy. There might be an emphasis on the progress, but the media mainly focus on the possibilities of synthetic biology in the future while there is less focus on current achievements. When certain achievements are made in the field, it gets picked up on by the media (such as the production of artemisinin by Keasling), but the emphasis is on what such achievements could mean or do in the future.

Different from the biotechnology debate is that there is little emphasis on the risks or on the ethics of synthetic biology. Often, risks are discussed shortly or the brought up risks are criticized. Ethical questions are raised, but hardly elaborated on. The media often refer to biotechnology when these topics come up, indicating that there is not much of a difference when within the two research fields when looking at these specific topics.

For now, the Dutch media mainly emphasize the current and future developments within synthetic biology, and the progress this could bring in several branches such as healthcare and bio-energy.

Experts believe that currently the media do not give enough attention to synthetic biology. This is partly due to the low amount of existing and concrete applications. When the media pick up on certain developments within the research field, they play a crucial role in forming a bridge between science and society. The media should always be critical though, and they should balance the different frames and should look at them from different point of views.

DISCUSSION

In this study it was found that synthetic biology is mainly represented in a positive way in the Dutch media. There is a focus on the progress that new developments could bring. Risks and ethics are discussed as well, but often not elaborated on. In this section, the limitations of the study will be discussed. Suggestions for further research will be given, as well as some recommendations on how the results of this study could be used to empower the public in future dialogue about synthetic biology.

Limitations

This research has a few limitations, which will be discusses below.

Search term

The only search term used to find media items was “synthetische biologie”. In earlier research, Gschmeidler and Seiringer (2012) found that in 35% of their analyzed newspaper articles the term “synthetic biology” was never used explicitly, but it was clear that synthetic biology was meant. This is mostly because synthetic biology is still seen as a part of biotechnology, thus the term is not always used explicitly. By only using the search term “synthetische biologie”, certain newspaper articles or video – and radio programs that covered synthetic biology – but did not explicitly mention it – might have been missed. The upside of only using the search term “synthetische biologie” is that it is certain that the analyzed documents are indeed about synthetic biology. The chance of misinterpretation is therefore low.

Limited analysis of newspaper articles

Not all found newspaper articles which included the search term "synthetische biologie” were analyzed. In the database LexisNexis 177 newspaper articles were found, of which 90 were analyzed. Furthermore, there is no existing database for all Dutch television – and radio programs, so the websites of all broadcasting stations were searched separately. Only the websites of the national broadcasters were searched, so certain documents of other (local) broadcasters that were about synthetic biology might have been missed. All of this means that a more complete view of the current representation of synthetic biology in the media could have been achieved, when all newspaper articles would have been analyzed or when local broadcasters would have been searched as well. This was not done due to time issues.

Only Dutch media items from Dutch broadcasters

Only the known Dutch media were analyzed, but people might get their scientific information from other sources such as YouTube, National Geographic or Discovery Channel as well. Even though those are not Dutch media, and are therefore not included in this study, they might still be a relevant source of information for citizens.

No distinction in newspapers or broadcasters

All the newspaper articles and programs were analyzed as a whole. In the results section it was explained why no distinction was made between the newspaper articles and the television – and radio programs, but it could have been interesting to make a distinction between different types of newspapers for example. Newspapers that focus on Christian readers, for instance, possibly frame their articles about synthetic biology very differently compared to a financial focused newspaper. The same is the case for television – and radio broadcasters. When this would have been studied, more insight could have been gained about how such different types of media frame their messages about synthetic biology, and what their views on it are. This would give more detailed knowledge about the representation of synthetic biology in the Dutch media.

Interviews

During the interviews with experts, Virgil Rerimassie and Michelle Post were interviewed together. It is possible they might have influenced each other's opinions. Next to this, Virgil Rerimassie and Michelle Post were already familiar with each other and had talked about certain topics that came forward in the interview before. On the other hand, being able to discuss the interview questions could have led to new or surprising insights as well, which would not have come forward when the interview was done separately. Last but not least, more experts could have been interviewed to get more insight in their views on synthetic biology in the media.

Recommendations

Based on the results of this research and the interviews held with experts, several recommendations can be made. Recommendations were conducted from the results of the analysis in combination with the answers experts gave to the interview questions. These recommendations could be used to empower people in social dialogue on synthetic biology. Therefore, these recommendations could be used in schools, in science cafes or by science communicators, or they could be used by the SYNENERGENE project, which has the main aim to foster dialogue on synthetic biology. The recommendations focus on what these communicators should be aware of when they want to stimulate dialogue on synthetic biology, or when they want to empower people for such dialogue.

More focus on current research and developments

Even though the frame that was used the most in the Dutch media was the progress frame, there was too little focus on the research that is currently done and the developments in the present. When the media emphasize the progress that synthetic biology brings, they mainly focus on promises for the future, like promises in healthcare or bio-energy. The media barely emphasize innovations in synthetic biology in the present. It is of importance to look at current developments and applications as well, instead of only looking at the future. Then, it is likely that people are more willing to talk or discuss synthetic biology, because it is already out there and it is not just from the future anymore.

Even though new developments and innovations can take some time to 'get out of the lab' and go public, there is still current progress within the field that could be focused on during dialogue. An example of this are the innovations of the worldwide iGem teams.

A balance of frames and a balance within frames

Frames like globalization or law & regulations are hardly covered in the media items. To give a more complete view about synthetic biology and every aspect that is involved, it is important that those other topics are brought forward as well. When stimulating dialogue, or when empowering people for dialogue, such other topics – like law & regulation or globalization – should come forward as well.

Another important aspect that should be emphasized, according to the experts, is the balance *within* frames. Questions should be raised, for example, about the progress that synthetic biology brings. Is the kind of progress that is being made progress for everyone, or only for a certain group of people?

More focus on the risks and ethics

Even though the risk frame and the ethics frame are found a lot in the media items, there is barely elaboration on these topics. Often, the risks and ethical questions involved in synthetic biology are only mentioned shortly or they are criticized. This is not always the case, sometimes these topics are explored in more depth like in the documentary "DNA hackers". Often though, the risks or ethics of synthetic biology are not the main focus in the media.

This does not mean that the risks or ethical questions are not important. When developments within synthetic biology increase or become more advanced, the risks involved could change or other ethical questions could be raised. These risks and ethical questions should then be explored in more depth, instead of only mentioning them, as is often the case now.

Involvement of religious groups

Expert Huib de Vriend believes it is important to involve different religious groups in the discussion about synthetic biology. Sometimes, certain groups are involved, but those are mostly Christian groups, the religion that is present in a large part of the western world. It would be interesting to get a more widely spread view on the different opinions there are in different religions about synthetic biology. Examples of religious groups that could be more involved are the Islam and the Judaism, but also the eastern religions such as Buddhism and Hinduism. This way, we could get more insight on the views from different groups in society, which can help stimulate dialogue. Next to this, it would be interesting to learn more about how different religions view this controversial research area and their input in discussions can broaden the views of others.

Further research

Further research that is based on the current study could be done in the future. This study does not give any insight in how people interpret the media that covers topics on synthetic biology.

A study could be conducted which looks at how people interpret the media that was used in the current study, to see if the coded frames are similar to the interpretations of the public. This way, it will be possible to make conclusions about if the interpretation of the media by the public is comparable to the way it was coded in this study. So if the media represent synthetic biology in one way, is it received by the public in the same way or not? This will give more insight in the representation of synthetic biology by the media and the interpretation of the media items.

Other research can be done on the influence the media has on the opinions and views that people have about synthetic biology. The research of Kronberger et al. (2012) showed that when group deliberation about synthetic biology in the media took place, people tended to get more involved in the subject and were stimulated to be more critical, reflective and politically aware. A study like this would give more insight in how the media influence opinions and it would give more insight as well in the opinions and views people have about synthetic biology.

Further research could be done to look what role the media could have in stimulating dialogue about synthetic biology. According to Virgil Rerimassie from the Rathenau Institute, it is important the public gets involved in the – current and upcoming – dialogue about synthetic biology. Then, the public can be part of the decision making process within this research field and they will be empowered to be active citizens. To look at what role the media could have in stimulating dialogue about synthetic biology, research could be done in schools for example, where the media that was used in this study could be used to stimulate dialogue. The research could focus on which articles are most stimulating and why, for example.

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APPENDIX I – CODES FOR MEDIA ANALYSIS ON SYNTHETIC BIOLOGY

The main codes are at the top and are from the media frames for scientific applications from Overbeek et al. (2014). Sub-codes were created while coding the media messages, as explained in the methods section. A description of every code is given below.

Progress

- P = **General code**. Progress because of synthetic biology is mentioned in general, or a form of progress is described that cannot be coded otherwise.
- P-B = **Biosensors**. Synthetic biology is used/could be used to make biosensors. Biosensors are sensors that can detect ('sense') certain aspects inside or outside of the body or in nature/the environment.
- P-C = **Carbon dioxide**. Synthetic biology is used/could be used for the uptake of carbon dioxide out of the air. It will create cleaner air.
- P-CV = **Craig Venter**. Use code when *achievements* in synthetic biology by Craig Venter are mentioned.
- P-Cr = **Criticism**. There is criticism on the progress in synthetic biology, or it could be someone does not think synthetic biology is revolutionary. The new field in biology is 'overrated' or the developments are 'overrated'.
- P-E = **Energy**. Synthetic biology is used/could be used to create (clean) energy or biofuel. Progress in the field of (clean) energy or biofuel.
- P-I = **Improvement**. Synthetic biology is used/could be used to improve nature, animals, humans or other organisms by altering their genetic structure.
- P-L = **Life (creating)**. Synthetic biology is used/could be used to create new – and possibly perfect – life (humans, animals, other organisms). Creating new life could mean creating *perfect* new life. 'Creating life' means creating from scratch.
- P-M = **Medication**. Synthetic biology is used/could be used to create new or better medication. Synthetic biology will be helpful in medical care.

Ethics

- Et = **General code**. The ethics involved with synthetic biology are mentioned in general, or something ethical is described that cannot be coded otherwise.
- Et-B = **Boundaries**. Synthetic biology searches/exceeds boundaries. Ethics on: How to protect boundaries? Is it moral to exceed those boundaries? Use code when (in)direct ethical questions or matters concerning boundaries come forward.
- Et-G = **God (playing for)**. Synthetic biologists 'are playing God' by using synthetic biology. Use code when ethical questions or matters concerning God come forward.
- Et-PH = **Perfect humans**. Synthetic biology could be used to create perfect human beings. A lot of ethics is involved with this. Use code when ethical questions or matters concerning perfect human beings come forward.

Risks

- R = **General code**. The risks that could rise with the developments of synthetic biology are mentioned in general, or a risk is described that cannot be coded otherwise.
- R-C = **Criticism**. There is criticism on the risks that are put forward that could arise from synthetic biology. The risks are minimized or it is explained why the risks are not realistic.
- R-E = **Escape (in the wild)**. Organisms created with synthetic biology could escape in the wild. This could have consequences for nature and for humans.
- R-W = **Weapons**. Synthetic biology could be used to create (biological) weapons. This could be done by, for example, bioterrorists. People can use synthetic biology for the wrong in any kind of way.

Economics

- Ec = **General code**. An economical aspect concerning synthetic biology is mentioned in general, or the economical aspect cannot be coded otherwise.
- Ec-I = **Investment**. Companies/governments/foundations invest in synthetic biology. This investment can have various reasons (progress or own benefit, for example).
- Ec-P = **Patent**. Innovations in the field of synthetic biology are patented.
- Ec-Pr = **Progress**. Developments within synthetic biology could create economical progress. Synthetic biology can create cheaper solutions for problems, for example.

Nature-nurture

- NN = **General code**. Synthetic biology could have an influence on nature/nurture. This could be extern (it is fate, uncontrollable, nature) or this could be intern (you can influence it, autonomy, nurture).

Globalization

- G = **General code**. Synthetic biology can have an influence on the world. It can influence world economy or help third world countries for example. Use code for the effects of synthetic biology worldwide.

Law and regulations

- LR = **General code**. Synthetic biology should/could come with (new) laws and regulations. Use code when existing laws and regulations are mentioned or when new ones are offered.

Social debate

- SD = **General code**. *Not a code for a media frame, not used in end results*. Use code when it is mentioned that social debate about synthetic biology (for example about risks and ethics) is important.

iGem competition

- I = **General code**. *Not a code for a media frame, not used in end results*. Use code when (part of) the article is about the *iGem competition, a competition in creating the 'best' innovation in synthetic biology.

  * *iGem = International genetically engineered machine*

APPENDIX II – EXPLANATION ON HOW TO CODE MEDIA MESSAGES

Below the explanation on how to code the media items which was send to the second coder.

You are coding 20% of the newspaper articles that I coded and 31% of the television – and radio programs. This means there are 18 randomly selected articles and 6 television – and radio programs. In the first file you find an explanation on the different codes that are available (*Appendix I*) and how to use them. In this file I will further explain what to do and how to work. If something is not completely clear (before, during or after the coding process) feel free to ask any questions about your concerns.

- You will receive 18 articles in 18 Word files. Every file contains one of the articles. In each article, the parts are highlighted for you which I coded myself, but the codes are absent. As a second coder you will have to code these selected parts. Use the code you think is right for every part. It is important though to read the whole article, to know what the context and content is and to be able to suggest improvements in the coding (see other points).
- You will also receive 6 television – or radio programs in the coding program Atlas.ti, in which you can code these programs the same way as the articles.
- There could be more than one code in every fragment that is highlighted. For example, when two codes are given to one fragment, a (2) will appear behind the fragment.
- When there is a small white gap between two highlighted parts in a newspaper article, this means that these parts can be coded as two different sentences.
- Titles can be coded as well.
- Sometimes a short summary of the article appears at the beginning of a newspaper article. This summary is not coded.
- The code I is for when the iGem competition is mentioned. When the competition is mentioned, only use the code *once*, so it is clear that the iGem competition makes an appearance in the fragment.

- When you believe there is a highlighted part that should not be coded, write this down and consult this with the researcher.
- When you believe a part should be coded that is *not* highlighted (and thus not coded by the researcher), write this down and consult with the researcher.
- When you believe a sub-code should be added or be deleted (so a (3) should become a (2) or the other way around), write this down and consult this with the researcher.
- Some codes can seem very similar or can be overlapping with one another. This could make it difficult to put one specific code to a highlighted fragment. When this is the case, make the decision for yourself to code the text with the code *you* feel like fits best and use this code every time you face the same problem (when you see a similar text with the same content/ideas). So be consistent.

After coding we will arrange a meeting to clear up any differences or unclear codings.
Thank you for your help.

APPENDIX III – LIST OF DUTCH TELEVISION – AND RADIO STATIONS

A list of the Dutch media channels that were searched for items about synthetic biology for this research.

Dutch television stations
NPO 1
NPO 2
NPO 3
RTL 4
RTL 5
RTL 7
RTL 8
SBS 6
SBS 9
NET 5
Veronica

Dutch radio stations
NPO Radio 1
NPO Radio 2
NPO 3FM
NPO Radio 4
NPO Radio 5
NPO Radio 6
FunX
Sky Radio
Radio Veronica
Q-music
BNR Nieuwsradio
Slam! FM
Radio 538
Radio 10
SubLime FM
100% NL

APPENDIX IV – LIST OF INCLUDED NEWSPAPER ARTICLES

A list of the newspaper articles that were used and coded in this research (n=90). The table includes the title of the article, the newspaper it was published in, the publication date, the word count of the article and the amount of codings done in the article.

#	Title	Newspaper	Publication date	Word count	Code count
1	"Creatief met leven: Achtergrond hoe de biologie de wereld gaat veranderen"	Vrij Nederland	24-11-2007	2437	30
2	"Gezocht: brandstofbacterie"	Trouw	29-06-2007	1443	19
3	"Lego van DNA: Synthetische biologen ontwerpen bacterie alsof het machientje is"	NRC Handelsblad	06-01-2007	2170	19
4	"Toekomst synthetische biologie – De mens gaat de schepping overdoen, maar dan beter"	Het Financieele Dagblad	22-10-2007	1359	21
5	"Stel grenzen aan het gesleutel aan de mens"	NRC Handelsblad	10-11-2007	2545	18
6	"Synthetisch leven stap dichterbij"	Trouw	29-06-2007	323	10
7	"Er vindt een verschuiving plaats binnen de biologie"	Leeuwarder Courant	13-10-2007	771	15
8	"Onruststokerij"	Het Financieele Dagblad	12-10-2007	566	21
9	"Meedenken over leven maken"	Reformatorisch Dagblad	19-10-2007	866	24
10	"Start discussie over synthetisch leven"	Trouw	18-07-2007	703	9
11	"Debat over synthetische biologie"	De Gelderlander	08-10-2008	270	18
12	"Kunstmatig leven verdient helder debat"	De Volkskrant	12-02-2008	798	4
13	"Leven maken"	NRC Handelsblad	05-04-2008	1376	5
14	"Nu doe-het-zelven ze al met DNA: synthetische	De Volkskrant	02-02-2008	1408	20

	biologie, nagemaakt bacteriegenoom brengt bouwen van levende wezens weer stap dichterbij"				
15	"Proeven aan de geknutselde men: Steekwoord chapeau"	De Volkskrant	20-12-2008	1578	4
16	"Creatief met genetische lego: Studenten bouwen thermometerbacterie in internationale competitie"	NRC Handelsblad	21-08-2008	701	25
17	"Genenkaart bacterie nagebouwd in lab"	De Volkskrant	26-01-2008	392	11
18	"Leven maken volgens Gronings ontwerp: Onderzoek synthetische biologie"	Dagblad De Pers	14-05-2008	676	6
19	"RUG start revolutionair centrum"	Dagblad van het Noorden	12-03-2008	430	11
20	"Kans op sterven hoger bij veel vet in de buik"	NRC.NEXT	18-11-2008	441	7
21	"Bacterie op mensenmaat"	Knack Magazine	28-01-2009	1733	23
22	"Estafette voor bacteriën: TU-team wint internationale prijs synthetische biologie"	AD/Haagsche Courant	06-11-2009	574	14
23	"Genetische modificatie? Kan me niet schelen!"	Boerderij Vandaag	10-04-2009	660	8
24	"Nooit ziek, zwak of misselijk: Is de toekomst aan de voorgeprogrammeerde nanomens? En zo ja, hoe goed is dat?"	NRC Handelsblad	11-12-2009	1562	11
25	"Tellen om te leven: Ontwikkeling"	Knack Magazine	29-07-2009	334	3
26	"Slimme bacteriën tegen kanker"	Knack Magazine	16-12-2009	683	4
27	"TU-studenten naar Boston voor racende bacterie"	AD/Haagsche Courant	30-10-2009	362	13
28	"Innovaties: Ooit bouwen	Het Financieele	18-04-2009	366	24

	we mensen"	Dagblad			
29	"Kunstmatig mensengenoom"	Knack Magazine	28-01-2009	387	11
30	"Studenten scoren met bacterie"	Dagblad van het Noorden	11-11-2009	123	16
31	"De maakbare mens is in aantocht: Er wordt volop gesleuteld aan lichaam en geest. Wat is er gaande? Wat zijn de risico's?"	Elsevier	06-11-2010	3925	9
32	"Letterlijk de wereld ontwerpen: Microsoft heeft nieuw doel"	NRC.NEXT	29-09-2010	815	13
33	"Levende bacteriën uit synthesizer"	De Volkskrant	22-05-2010	752	5
34	"Tekentafel leven uit de computer, zegt Craig Venter"	Nederlands Dagblad	18-06-2010	830	15
35	"Wetenschappers zetten prachtige en belangrijke stap in kinderschoenen"	Reformatorisch Dagblad	29-05-2010	811	11
36	"Facebook kraakt privacy, biologen spelen God"	Trouw	25-05-2010	627	3
37	"Geboren: JCVI-syn1.0"	NRC Handelsblad	05-06-2010	2801	10
38	"Groningse studenten winnen prijs in Boston"	Dagblad van het Noorden	12-11-2010	101	5
39	"Kort: Synthetische bacterie knippert groepsgewijs"	De Volkskrant	23-01-2010	537	15
40	"Leven uit de computer"	Leeuwarder Courant	26-06-2010	824	29
41	"Alsof de landbouw nog natuurlijk is"	De Volkskrant	01-09-2011	1967	8
42	"Hacker van het leven"	NRC Handelsblad	15-10-2011	2074	8
43	"Het geheimzinnige genoom"	Knack Magazine	02-11-2011	1254	14
44	"Synthetische virussen op komst"	NRC Handelsblad	03-01-2011	1693	9
45	"Bacteriën bouwen met biobakstenen: Delftse studenten doen mee aan	NRC Handelsblad	30-09-2011	780	14

	internationale competitie biologisch ontwerpen”				
46	“Tellende bacterie naar Boston”	Dagblad van het Noorden	02-11-2011	153	6
47	“Miljoenen knipperende bacteriën: Reportage inzendingen van Wageningen universiteit voor MIT-studentenprijs”	De Volkskrant	30-09-2011	563	16
48	“Plant kan leren van een zonnecel: Genmanipulatie voor betere fotosynthese”	NRC.NEXT	24-05-2011	692	4
49	“Uitgeklede bacterie”	NRC Handelsblad	23-07-2011	1929	10
50	“Zelf een virusje maken: Bioloog Lu over kunstvirussen”	NRC.NEXT	04-01-2011	697	19
51	“Bewaren of weggooien?”	NRC Handelsblad	10-11-2012	1093	4
52	“Biologen met een schroevendraaier”	Het Parool	28-07-2012	645	5
53	“Ingenieurs van het leven”	Dagblad De Limburger	21-03-2012	994	12
54	“Leven maken”	Nederlands Dagblad	04-05-2012	822	5
55	“We gaan leven programmeren”	De Volkskrant	19-05-2012	1479	2
56	“Bacteriën produceren grondstoffen”	Nederlands Dagblad	08-10-2012	303	7
57	“De nieuwe biotech”	De Volkskrant	11-02-2012	325	2
58	“Fijne vakantie, gewoon thuis, in het lab”	NRC Handelsblad	07-08-2012	1232	3
59	“Groningse studenten beste bacteriebouwers ter wereld”	Dagblad van het Noorden	07-11-2012	323	7
60	“Sticker herkent bedorven vlees”	Dagblad van het Noorden	10-10-2012	195	2
61	“De nieuwe bouwsteen van het leven heet XNA”	NRC.NEXT	23-11-2013	945	9
62	“Algen melken voor brandstof”	Spits	21-01-2013	602	23
63	“Nog even doorjubelen over synthetische bio: Deze	NRC Handelsblad	23-11-2013	464	2

	week”				
64	“Op weg naar designer-DNA”	Nederlands Dagblad	25-05-2013	1113	1
65	“Zonder publiek debat zetten we leven naar onze hand”	Nederlands Dagblad	11-11-2013	790	13
66	“Adapter voorspelt enzymproductie van een bacterie”	NRC Handelsblad	16-03-2013	382	3
67	“Mammoeten knutselen, mag dat?”	Nederlands Dagblad	03-04-2013	238	6
68	“MRSA bestrijden via kikker”	Het Parool	15-10-2013	449	6
69	“Ophef over lichtgevende plantjes”	Nederlands Dagblad	11-05-2013	230	11
70	“Verleden en toekomst van het leven”	Nederlands Dagblad	18-10-2013	702	9
71	“19-jarige bedacht Barrie de bacterie”	Eindhovens Dagblad	21-11-2014	433	3
72	“Allemaal eng”	De Volkskrant	27-09-2014	1915	5
73	“Kunstmatig chromosoom in gistcel”	De Volkskrant	28-03-2014	436	5
74	“Puzzelen met biobouwstenen: Synthetische biologie neemt hoge vlucht”	Knack Magazine	16-07-2014	1978	3
75	“Sleutelen zullen we: Kunstmatig van nature”	Trouw	25-01-2014	2493	3
76	“De taal van de genen krijgen twee nieuwe letters”	NRC Handelsblad	10-05-2014	691	2
77	“Het geweten”	Vrij Nederland	09-08-2014	674	10
78	“Nagemaakt chromosoom stap naar kunstmatig leven”	Nederlands Dagblad	28-03-2014	571	6
79	“TU Delft naar wedstrijd MIT”	Delftse Post	15-10-2014	197	4
80	“Wetenschappers VS bouwen kunstmatig chromosoom”	Reformatorisch Dagblad	29-03-2014	428	5
81	“Christenen, denk mee over maken van leven”	Nederlands Dagblad	27-02-2015	463	7
82	“Leven 2.0 kan geen	De Volkskrant	22-01-2015	556	6

	kwaad in de natuur”				
83	“Bacterie met ingebouwde handboeien”	NRC Handelsblad	24-01-2014	907	6
84	“Een antwoord voor Bill Gates”	Eindhovens Dagblad	21-01-2015	864	2
85	“Wat als je zelf leven kunt bouwen?”	Nederlands Dagblad	13-02-2015	1423	5
86	“Nieuw gezicht”	De Volkskrant	24-01-2015	268	3
87	“Plant krijgt schakelaar tegen droogte”	Nederlands Dagblad	07-02-2015	304	3
88	“Gentse biofarmabedrijf ActoGenix in Amerikaanse handen”	Nieuwsblad BE	13-02-2015	136	2
89	“12 manieren waarop de mensheid kan verdwijnen: Synthetische biologie”	De Redactie BE	15-02-2015	49	3
90	“Precisie antibiotica”	NRC Handelsblad	28-03-2015	2233	12

APPENDIX V – LIST OF INCLUDED TELEVISION SHOWS AND RADIO FRAGMENTS

A list of the television shows and radio fragments that were used and coded in this research (n=19). The table includes the source (television or radio), the broadcaster, the broadcasting date, the total length in minutes, the length in minutes that was really focusing on synthetic biology (effective length) and the amount of codings done.

#	Medium	Broadcaster	Broadcast date	Total length	Effective length	Code count
1	TV	VPRO Buitenhof	16-09-2007	52 min.	10 min.	11
2	TV	VPRO Buitenhof	23-03-2008	54 min.	54 min.	28
3	TV	RUG "Adams Appel"	28-05-2009	7 min.	7 min.	8
4	TV	NPO Labyrint "DNA hackers"	21-04-2010	33 min.	33 min.	46
5	TV	VPRO Llowlab "Leer een gistcel ruiken"	29-08-2012	2:40 min.	2:40 min.	4
6	Radio	NPO Noorderlicht	18-01-2005	54 min.	9 min.	6
7	Radio	NPO Noorderlicht	16-12-2008	30 min.	10 min.	3
8	Radio	NTR Hoe? Zo! Radio Teleac	01-01-2009	55 min.	55 min.	3
9	Radio	NTR Hoe? Zo! Radio Teleac	11-08-2009	47 min.	2 min.	6
10	Radio	NPO Noorderlicht	09-11-2009	25 min.	14 min.	15
11	Radio	BNR	19-07-2011	10 min.	10 min.	19
12	Radio	NTR Hoe? Zo! Radio Teleac	29-12-2011	37 min.	37 min.	5
13	Radio	NPO Radio 1 Labyrint	20-08-2012	13 min.	13 min.	4
14	Radio	NPO Radio 1 Labyrint	18-11-2012	16 min.	12 min.	4
15	Radio	Villa VPRO	27-03-2013	60 min.	5 min.	9
16	Radio	Radio 5 OBA live	31-05-2013	60 min.	6 min.	2
17	Radio	BNR	10-11-2014	2:30 min.	2:30 min.	2
18	Radio	NPO Radio 1 "De kennis van nu"	15-04-2015	60 min.	60 min.	21
19	Radio	NPO Radio 1 "De kennis van nu"	24-06-2015	25 min.	25 min.	6

APPENDIX VI – INTERVIEW QUESTIONS

In this appendix the questions that were asked during the interviews with the experts are shown. As explained in the Methods, three experts were interviewed.

General questions

- Name, work/function?
- What is your affinity with synthetic biology?
- Do you think the media* gives enough attention to synthetic biology? Why?

Importance of synthetic biology in the media

- Why do you think it is/is not important that there is attention for synthetic biology in the media?
- What do you hope can be achieved when the media gives attention to synthetic biology?
    - Do you believe that something is achieved currently?

Framing of synthetic biology

My research shows that there are three subjects/perspectives that come forward the most in the media (framing): (1) the progress that synthetic biology causes, (2) the risks it brings, and (3) the ethical questions that rise.

- In your opinion, are the three main points discussed most?
- Do you think there are any subjects that are not discussed or that are important as well?
- Within these three main perspectives, what do you think are the most important subjects that the media should discuss?

Other questions

- Do you have any other comments or remarks about the representation of synthetic biology in the Dutch media, that are not discussed yet during this interview?

** Media are newspapers, television and radio.*